

Long Term Memory for Knowledge Taught in School

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FOREWORD

The experimental study of knowledge retention was conducted at the University of Kansas under the Personnel, Training, and Human Factors Technology (NP2A) Block of the 6.2 Mission Support Technology Program Element 0602233N and Work Unit RM33T23.05, which was sponsored by the Chief of Naval Research (ONT-222). The goal of this study was to determine how well information taught in school is retained. The recommendations provided in this report are intended for use by the Chief of Naval Education and Training and the Chief of Naval Technical Training in determining instructional strategies for teaching knowledge in Navy classrooms. They are also used in an advanced development 6.3 project to develop and test instructional techniques for the classrooms of the future.

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SUMMARY

Problem and Background

Military trainees frequently do not retain much of what they have been taught in school by the **time they start** working on the job. However, much of the research on this problem has focused on **procedural/psychomotor** skills and tasks (e.g., performing preventive maintenance, operating equipment). While the research on skill retention has been extensive, there has not been much work on memory for knowledge taught in school.

Objective

The primary objective of this effort was to determine the amount of information students retain from an introductory college course 4- and 11-months after completing the course. The course was an introductory child psychology course that taught facts, concepts, and principles and required some problem solving.

A second objective was to determine if the amount of information retained by students taught in a self-paced course differs from that retained by students taught in a group-paced, lecture discussion course.

Method

The experiment compared students taught by two different methods, self-paced versus group-paced instruction, on original learning, retention after 4 months and retention after 11 months. Because it was impossible to retest all the students who took the 4-month retention exam at the 11-month interval, the two retention intervals involved different numbers of students--the 11-month group was a subset of the 4-month group. In the group-paced condition, there were **36** subjects at the 4-month interval and 18 at the 11-month interval. In the self-paced condition, there were **44** subjects at the 4-month interval and 19 at the 11-month interval. The primary performance measure was the score on the end-of-course exam composed of multiple-choice and true-false items that tested student ability to recognize information learned during the course. There were four forms of the exam and, at the 4-month interval, students were retested with the same form they took at the end of the course and were also tested with a different form. Students took the same two tests at the 11-month interval that they had taken at the 4-month interval.

Results

A repeated measures, analysis of variance (**ANOVA**), revealed significant decline in performance between the end-of-course test and the 4-month retention test, and between the 4-month and 11-month interval. Specifically, the results were that: (1) students retained approximately **85** percent after 4 months and about 80 percent after 11 months; (2) self-paced students performed significantly better on all tests at both intervals than did group-paced students; (3) the amount of information lost did not differ significantly between groups across the two retention intervals; and (4) the amount of information lost relative to initial learning did not differ significantly between groups across the two retention intervals.

Concluding Remarks

It is important to emphasize that this study focused on the ability to **recognize** information learned in school. There were no measures of the ability to recall information or solve problems. However, the types of recognition test items **used** in this study (i.e. multiple-choice and true-false

items) are identical to those used in most Navy introductory courses. Therefore, because the test item formats were identical and because **of** the similarities in the type of information taught **in** University of Kansas course and in introductory Navy technical courses (e.g. names, definitions, principles), it can be concluded that students will be able to **recognize** knowledge learned in Navy technical classrooms even after an 11-month retention interval. Further research is planned to investigate students' ability to recall information learned in school.

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INTRODUCTION

Problem and Background

Military trainees frequently do not retain much of what they have been taught in school by the time they **start** working on the job (Schendel, Shields, & Katz, 1978; Vineberg, 1975; Hagman & Rose, 1983). Some of the factors that have been shown to contribute to this loss include type and complexity of the job-task, amount and quality of the initial training, length of time without practice, and amount and quality of experience encountered on-the-job (Montague, Wetzel, & Konoske, 1983; **Farr**, 1986).

Much of the research on skill and knowledge retention has focused on procedural/psychomotor skills and tasks (e.g., performing preventive maintenance, operating equipment). After a number of years of research on these types of tasks, the Army integrated the findings and published a *User's Manual for Predicting Military Task Retention* with an accompanying form, **TRADOC Form 321-R**.

While the research on skill retention has been extensive, memory for knowledge taught in school has received little attention (Neisser, 1982). The conventional wisdom is that most of what is learned in school is quickly forgotten. In a book on memory, Higbee (1977) states that "people . . . forget what they learned in school (usually within a short time after **an** exam)." Bahrck (1979) says that "much of the information acquired in classrooms is lost soon after final examinations are taken." However, studies conducted in the first half of this century provide some evidence that this may not be the case (Johnson, 1936; Wert, 1937). In a more recent study, Ellis (1980) found that Navy 'A' School students lost very little information over a 6-month retention period.

Memory for knowledge learned in school is a very important issue. In the civilian world, the very existence of high school and college education rests on the assumption that people remember something of what they learn. In the military, knowledge retention is even more critical. Presumably, the knowledge that students learn in **military** classrooms is prerequisite for knowing when and how to perform jobs and tasks in the real world. Thus, it is important to know how much and what kind of knowledge students remember. Unfortunately, according to Neisser (1982), "It is difficult to find even a single study, ancient or modern, of what is retained from academic instruction." Recently, Bahrck (1984) found that even after 50 years, subjects retained a substantial amount of Spanish learned in school. However, not much research has studied memory for the type of knowledge that college students learn in introductory courses or Navy personnel learn in apprentice training courses.

Although, the content of college introductory courses and Navy apprentice training courses may be quite different, the strategies for teaching and learning that content are very much the same. In some cases, such as college physics and Navy basic electricity training, even the content is **similar**. Basically, both types of courses teach facts (e.g, names, dates, definitions), introductory concepts and principles, and, in some courses, problem solving skills. Thus, examining what college students retain from **an** introductory college course should tell us something about what Navy personnel will retain from a Navy apprentice course.

Objective

The primary objective of this effort was to determine the amount of information students retain from an introductory college course 4- and 11-months after completing the course. The course was an introductory child psychology course that taught facts, concepts, and principles and required some problem solving.

A second objective was to determine if the amount of information retained by students taught in a self-paced course differs from that retained by students taught in a group-paced, lecture discussion course.

METHOD

Subjects and Setting

Subjects were students enrolled in 14 sections of a one-semester introductory child psychology course at the University of Kansas. The course was taught in two formats: group-paced, lecture discussion, two sections and self-paced, 12 sections. Only students who were not psychology majors, who took the comprehensive final exam at the end of the semester, and who agreed to participate in the study by signing a University-approved research consent form and for whom American College Test (ACT) test scores and University grade-point averages were available were considered for inclusion as subjects. Psychology majors were excluded because they were likely to take additional psychology courses during the retention interval. Students who were actually included as subjects took both forms of the retention exams at each of the two retention intervals. Because all the students who took the 4-month retention exam could not be retested at the 11-month interval, the two retention intervals involved different numbers of students--the 11-month group was a subset of the 4-month group. The group-paced condition included 36 subjects at the 4-month interval and 18 at the 11-month interval; the self-paced condition, 44 subjects at the 4-month interval and 19 at the 11-month interval.

Instructional Procedures

The course was divided into twelve content units, each of which covered about one chapter in the course text and accompanying study guide. All students took a 14-item quiz at the end of each unit and a 28-item midterm exam after every fourth unit. Quizzes and midterms consisted of a mixture of true-false and multiple-choice items. The course ended with a comprehensive 72-item final exam.

Self-paced Instruction

Students in the self-paced sections worked at their own rate. They reported to class to work with the teaching staff and to take tests. Each section had 42 students and a staff of five undergraduate proctors and a graduate teaching assistant.

There were four forms of the unit quizzes and midterm exams. Students who answered less than 11 of 14 on a unit quiz correctly were required to (1) show their proctor a completed study guide for that unit and (2) retake an alternate form of the quiz. To progress in the course, students

had to retake unit quizzes until they earned a score of 11 or better. They could take unit quizzes as many as four times.

Students who answered less than **14** of the **28** items on the midterm exam correctly were required to take an alternate form; those who answered more than 14 correctly could retake it to try to improve their score. The highest score on the midterm exam counted toward the student's grade in the course. Students could only take the midterms twice.

There were three parallel forms of the comprehensive end-of-course exam. Students could take the exam twice and the highest score was counted.

Group-paced Instruction

Students in the two group-paced sections met with an instructor twice a week. The instructor lectured, administered quizzes and midterms, and discussed course content with students. Group-paced students had two chances to take each quiz (as opposed to up to four chances for self-paced students), midterm, and the final and the highest score counted toward their grade in the course. The final exam and administration procedures for the group-paced sections was the same as for the self-paced sections.

Experimental Procedures

The primary dependent measure in this study was the comprehensive final exam. Each of the four parallel forms contained 16 true-false items and 56 multiple-choice items. Three of the forms were used in the classroom as the final exam; the fourth form was reserved for use as one of the retention measures. Each form contained **6** items for each of the 12 units in the course. The items emphasized the major concepts covered in the course and were selected from a pool of over 1,300 items. Within each item type (true-false and multiple-choice) and within each concept area, four questions were selected for each form. Items were assigned to forms randomly from this stratified sample. No item appeared on more than one form of the exam. Furthermore, each form contained no more than 36 items that appeared elsewhere in the course (quizzes, review exams, and study guide).

Since all four forms of the exam had been used before this study, we were able to analyze how equivalent they were. The differences among forms was not statistically different. The final exams were not used as pretests in the present study; however, an analysis of results from **comparable** forms of the exams from previous semesters yielded mean pretest scores of **44** to **48** percent correct,

Students were instructed to answer each item on the exam and to indicate how confident they were that they had selected the correct answer. The confidence rating scale was the following five-point Likert scale:

- 5--Absolutely certain my answer is correct.
- 4--Highly certain my answer is correct.
- 3--Moderately certain my answer is correct.
- 2--Only slightly certain my answer is correct.
- 1--Uncertain(a guess).

The first set of retention exams was administered 4 months after the course ended. Students who met the eligibility criteria were contacted by telephone in mid-March and invited to take the retention exams later in the month. **As** an incentive to participate, they were offered a chance to participate in a “lottery” in which they had a 1 in 10 chance to win \$15 and a 1 in 100 chance to win \$100. **All** students who agreed to participate took two retention exams: One exam they had not seen before (different) and the identical form on which they had scored highest during the previous semester (same). The order of presentation of the exams was counter-balanced; students were assigned to same-different exam or different-same exam orders at random.

The second set of retention exams was administered 11 months after the course ended. Students were contacted by telephone in mid-October and invited to take the retention exams later in the month. **As** an incentive, subjects were offered \$10 to retake the exams. Students took the same two retention exams, the form they had taken at the 4-month retention test (different) and the identical form on which they had scored the highest during the semester they took the course (same).

The order of presentation of same/different exams was again counter-balanced for same versus different exam forms and for 4- versus 11-month intervals. That is, there were four possible combinations: (1) 4-month, same-different; 11-month, same-different; (2) 4-month, same-different; 11-month, different-same; (3) 4-month, different-same; 11-month, same-different; and (4) 4-month, different-same; 11-month, different-same. Students again were asked to rate their confidence in the correctness of their responses.

RESULTS AND DISCUSSION

The two retention intervals involved different numbers of students--the 11-month group was a subset of the 4-month group. Data for each group were analyzed separately.

Demographic Variables

The group-paced and self-paced subjects did not differ significantly on any of the demographic measures for either of the retention intervals. At 4 and 11 months, there were no significant differences for ACT-Composite, for grade-point average, or for year in school.

Same/Different Exam Order Effects

A repeated measures, analysis of variance (ANOVA), revealed a significantly higher score (percentage correct) for self-paced students at the end of 4 months, $F(1,76) = 40.2$, $p < 0.01$, $MSe = 55.6$, but no significant differences for the order of presentation of the exams (different-same versus same-different). Since order of presentation produced no effect, it was not part of the analyses of the 11-month group.

Academic Performance

Overall Percentage Correct

Table 1 presents the performance means for the 4-month retention group on the end-of-course and both retention exams. **A 2** (self-paced vs. group-paced) by **3** (end-of-course score vs. same

score vs. different score) repeated measures ANOVA revealed significantly higher scores for self-paced students, $F(1,78) = 41.5$, $p < 0.01$, $MSe = 84.6$, and significantly lower scores for both groups at 4-months versus end of the course, $F(2,156) = 215.0$, $p < 0.01$, $MSe = 8.9$. There was no significant interaction. Post-hoc comparison revealed that scores on the (1) same form of the exam were higher than on the different form, $t(79) = 7.5$, $p < 0.01$, (2) end of course exam were higher than on same form 4 months later, $t(79) = 13.6$, $p < 0.01$, and (3) end of course exam were also higher than on the different form 4 months later, $t(79) = 21.4$, $p < 0.01$.

Table 1
Performance Means for the 4-Month Interval
(Percent Correct by Condition)

	Self-paced	Group-paced
End of Course Exam	87.3	76.1
Same Form	78.6	68.5
Loss	-8.7	-7.6
Relative Loss	-9.9	-10.0
Different Form	73.5	62.8
Loss	-13.8	-13.3
Relative Loss	-15.8	-17.5

Table 2 presents the performance means for the 11-month retention group on the end of course and both retention exams. A 2 (self-paced vs. group-paced) by 3 (end-of-course score vs. 4-month same score vs. 11-month same score) repeated measures ANOVA for the same form of the exam revealed significantly higher scores for self-paced students, $F(1,35) = 14.7$, $p < 0.01$, $MSe = 86.3$, and significantly lower scores after 11 months for all students compared to end-of-course and 4-month performance, $F(2,70) = 72.2$, $p < 0.01$, $MSe = 10.5$. There were no significant interactions. An identical repeated measures ANOVA for different forms of the exam revealed similar findings for teaching conditions, $F(1,35) = 24.9$, $p < 0.01$, $MSe = 46.4$, and retention intervals, $F(2,70) = 98.4$, $p < 0.01$, $MSe = 16.6$. Again, there were no significant interactions. All post-hoc t-tests comparing the various forms and intervals were statistically significant at $p < 0.01$.

Loss

Tables 1 and 2 present the loss in score between the end of the course and the two retention exams. A 2 (self-paced vs. group-paced) by 2 (same vs. different) ANOVA showed that, at the end of 4 months, the only significant difference was that scores for the same form were higher than scores for the different form of the exam, $F(1,78) = 55.9$, $p < 0.01$, $MSe = 10.8$. There were no significant differences between groups, nor were there any significant between-or-within subject interactions. A 2 (self-paced vs. group-paced) by 2 (4 months vs. 11 months) by 2 (same vs. different) ANOVA revealed no significant effects for teaching condition. Scores were significantly lower after 11 months, $F(1,35) = 25.4$, $p < 0.05$, $MSe = 25.1$ and scores on the same form were higher than on the different form at both 4 and 11 months, $F(1,35) = 13.1$, $p < 0.01$, $MSe = 11.1$.

Table 2
Performance Means for the 11-Month Interval
(Percent Correct by Condition)

	Self-paced	Group-pad
End of Course Exam	87.3	78.4
Same Form	76.3	64.6
Loss	-11.0	-13.8
Relative Loss	-12.6	-17.6
Different Form	68.9	61.0
Loss	-18.4	-17.4
Relative Loss	-21.1	-22.2

Relative Loss

Tables 1 and 2 present the score lost relative to initial learning for the 4-month and 11-month retention groups. Relative loss was defined as the score lost adjusted for initial learning and was calculated by dividing the percentage lost by the percentage correct score at the end course (initial learning).

A 2 (self-paced vs. group-paced) by 2 (4 months vs. 11 months) by 2 (same vs. different) ANOVA on relative loss revealed no significant effects for teaching condition. Scores were significantly lower after 11 months, $F(1,35) = 21.4$, $p < 0.05$, $MSe = 52.8$ and scores on the same form were higher than on the different form at both 4 and 11 months, $F(1,35) = 18.7$, $p < 0.01$, $MSe = 71.2$.

Academic Performance: Discussion

The results for all measures of academic performance support the position that students retained a great deal of what they had originally learned: approximately 85 percent after 4 months and about 80 percent after 11 months. These findings are congruent with what others have found (e.g., Ellis, 1980; Bahrck, 1984) in studies of retention among adults with knowledge-based materials. They do not support the belief that most of what is learned in school is quickly forgotten.

These results also clearly support others who have found that the amount of original learning is an important determinant of retention (Farr, 1986). This is supported by the finding that the higher level of performance for self-paced students on the end of course exam was maintained across the 4-month and 11-month retention intervals.

Further, in this study, the teaching method made a difference in both the amount of original learning and the amount retained. The performance of self-paced students was superior to that of group-paced students on both measures. One explanation for this finding is that the groups received different amounts of testing during the course. Self-paced students could take each quiz up to four

times while group-paced students had a maximum of two chances. An analysis of the quiz data shows that self-paced students averaged **16.2** quizzes during the semester while group-paced students averaged **11.3** ($t(78) = 5.37$, $p < .001$). In terms of test items, this means that self-paced students were exposed to **227** items while group-paced students only saw **158**. Self-paced students were also required to complete a study guide and consult with their proctor when they did not meet criterion on a quiz. Thus, self-paced students had more exposure/practice with the type of items that were on the final exam as well as more enriched study and feedback on the areas in which they were weak. This differential treatment could account for the observed performance differences.

Finally, although there were significant differences between the self-paced and group-paced condition in the amount learned and retained, neither the amount of information lost nor the amount lost relative to initial learning differed significantly between groups across the **two** retention intervals.

Confidence Ratings

Overall Correct Confidence

Table 3 presents the confidence rating data for the 4-month group. For this study, we defined correct confidence as the sum of all the confidence ratings for items answered incorrectly subtracted from the sum of the ratings for items answered correctly. This means that, if someone got a perfect score on the **72** item test and rated each answer as **5** (absolutely certain), they would receive a correct confidence score of 360 (**72** items correct times **5** minus 0 for no items answered incorrectly). If a person missed all the items and also rated each answer as **5**, the correct confidence score would be **-360** (0 items scored correctly minus **5** times **72** items). The measure was designed to combine both the correctness of the response and the student's confidence about it,

Table 3
Confidence Means for the 4-Month Interval

	Self-paced	Group-paced
End of Course Exam	223.7	151.7
Same Form	167.5	109.9
Actual Loss	-56.2	-41.8
Percent Loss	-25.1	-27.5
Different Form	135.0	79.8
Actual Loss	-88.7	-71.9
Percent Loss	-39.6	-47.4

A **2** (self-paced vs. group-paced) by **3** (end-of-course score vs. same score vs. different score) repeated measures ANOVA for the 4-month group showed that self-paced students were significantly more confident than group-paced students, $F(1,78) = 39.8$, $p < 0.01$, $MSe = 565.8$, and that confidence declined significantly across the 4-month retention interval, $F(2,156) = 199.5$, $p < 0.001$.

0.01, $MSe = 649.7$. There was no significant interaction. Post-hoc comparison revealed that confidence was greater for the (1) same versus different form of the exam, $t(79) = 8.08$, $p < 0.01$, (2) end-of-course versus same form, $t(79) = 12.1$, $p < 0.01$, and (3) end-of-course versus different form, $t(79) = 19.3$, $p < 0.01$.

Table 4 presents correct confidence means for the 11-month retention group. A 2 by 3 repeated measures ANOVA for the same form of the exam revealed that self-paced students were significantly more confident, $F(1,35) = 11.43$, $p < 0.01$, $MSe = 6320.2$, and that confidence declined across the 4- and 11-month retention intervals, $F(2,70) = 91.5$, $p < 0.01$, $MSe = 1182.2$. There was no significant interaction. An identical repeated measures ANOVA for different forms of the exam showed that self-paced students were significantly more confident, $F(1,35) = 17.2$, $p < 0.01$, $MSe = 3414.53$, and that confidence declined significantly across the 4- and 11-month retention intervals, $F(2,70) = 154.0$, $p < 0.01$, $MSe = 1073.9$. Again, there was no significant interaction. All post-hoc t-tests comparing the various forms and intervals were statistically significant at $p < 0.01$.

Table 4
Confidence Means for the 11-Month Interval

	Self-paced	Group-paced
End of Course	226.8	164.9
Same Form	109.7	66.2
Actual Loss	-117.1	-98.7
Percent Loss	-51.6	-59.8
Different Form	73.2	52.8
Actual Loss	-153.6	-112.1
Percent Loss	-67.7	-67.9

Actual Loss

Tables 3 and 4 present the loss of correct confidence at the end of each retention interval. At the end of 4 months, the students were more confident of their responses on the same than on the different form of the retention exams, $F(1,76) = 62.3$, $p < 0.01$, $MSe = 622.2$. The difference in confidence between self-paced and group-paced conditions was marginally significant, $F(1,76) = 4.60$, $p < 0.05$, $MSe = 2118.2$, such that self-paced lost more than group-paced. There were no significant between- or within-subject interactions. At the end of 11 months, there were no significant differences between teaching conditions for the same form of the retention exam, but self-paced students lost marginally more on the different form than group-paced students, $F(1,36) = 4.69$, $p < 0.05$, $MSe = 3285.4$.

Percent Loss

Tables 3 and 4 also present the percent of correct confidence loss relative to initial confidence (at end of course). The percent loss was calculated by dividing the amount of confidence lost by the amount of confidence present at the end of the course (initial correct confidence).

At the end of 4 months, there was no significant difference in the relative amount of confidence lost between conditions on the same form of the retention exam; however, group-paced students lost marginally more confidence than self-paced students on the different form, $F(1,79) = 5.54$, $P < 0.05$, $MSe = 330.5$. At the end of 11 months, there were no significant differences between teaching conditions on the same or different forms of the exam.

Confidence Ratings: Discussion

Self-paced students were significantly more correct in their confidence ratings than group-paced students at the end of the course and at the end of both of the retention intervals. Both groups had higher confidence ratings on the same form of the retention exam than on the different form and this difference was constant across the two retention intervals. Further, both groups' confidence and relative confidence decline at approximately the same rate for both forms of the retention test (there was a marginal difference in favor of the self-paced students on the different form at the 4-month interval). The explanation for the differences in confidence is the same as the explanation for the differences in performance: Self-paced students saw more test items and had richer more extensive feedback than group-paced students. Thus, they were more confident of their answers on the final exam.

CONCLUDING REMARKS AND FUTURE EFFORTS

In the introduction in this study, we assumed that the type of information taught in this introductory child psychology course is similar to the type of information taught in Navy technical classrooms. That is, the University of Kansas course and most Navy apprentice classrooms emphasize remembering facts (names, functions, definitions), rules (formulas, laws), and principles (cause and effect relationships). Some college and Navy courses deal with problem solving (e.g., introductory physics in college and basic electricity in the Navy) and many Navy courses (and some college courses) have laboratory sections that focus on learning procedures. But, the primary focus in both types of course is on remembering information.

A second similarity between this study and Navy courses is the way the self-paced students were treated. Granted the Navy has few if any self-paced courses, but the goal of Navy technical training is to have people complete training, not weed them out. **Thus**, the opportunity for students to remediate and retest in the self-paced course is similar to the way Navy students are typically treated. In Navy courses, students who are having problems are assigned to night study, given on-the-spot remediation, or can be "set back" to restudy/relearn the course material.

These similarities mean that we can expect retention for both types of courses to be similar. In fact, the findings in this study are very similar to what Ellis (1980) found in a study of what Navy students remembered from an introductory propulsion engineering course after 1 month and 6 months. However, there are two concerns that affect this conclusion. First, all the test items in the

Kansas course were multiple-choice, true-false, or matching. That is, only the ability to recognize information was tested. We do not know if the retention of test items that required recall of information would be similar; however, previous research on recall memory has found lower performance. We are currently conducting a follow-up study to investigate this issue. The follow-up study should be completed in **FY 91**. The second concern is that there is some evidence that students come into the child psychology course with some prior knowledge of the content. This is less likely to be true of a Navy technical course. Therefore, while the retention may still be similar, the amount of learning may differ. A solution to this concern is to collect data on a Navy introductory course to verify and validate the present findings. This is difficult to do because Navy students are hard to track after they have graduated from school. Further, it is difficult to determine/control what Navy students experience during the retention interval. Ideally, their work should be related to what they learned in school which would confound any conclusions about amount of information remembered. College students, on the other hand, are likely to return the following year (unless they graduate, transfer, or drop out) and it is easy to determine what courses they have taken in the interim. However, the possibility will be explored.

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